E.J.B. 412

U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1510

ANTHRACNOSE AS A CAUSE OF RED CLOVER FAILURE IN THE SOUTHERN PART OF THE CLOVER BELT

IMPERIAL BUREAU OF MYCOLOGY 21 JAN

A DISEASE of red clover prevalent in some of the Southern States is described in this bulletin.

A remedy for the trouble is discussed and measures are outlined for the production of seed of resistant strains or for the more advantageous use of seed from nonresistant strains.

Washington, D. C. Issued November, 1926

ANTHRACNOSE AS A CAUSE OF RED-CLOVER FAILURE IN THE SOUTHERN PART OF THE CLOVER BELT

By A. J. PIETERS, *Agronomist, Office of Forage Crops*, and JOHN MONTEITH, JR., *Associate Pathologist, Office of Vegetable and Forage Diseases, Bureau of Plant Industry*

CONTENTS

	Page		Page
Decline in red-clover culture	1	Experience at Arlington Experiment Farm with clover seed of various origins	9
Anthracnose one cause of red-clover failure	1	Experience at State agricultural experiment stations	11
History and distribution of anthracnose	2	What is the remedy?	12
Symptoms of the disease	3	Development of resistant strains	13
Nature of injury the first season	3	Development of seed supplies	14
Nature of injury the second season	6	Fall rather than spring seeding	16
Conditions affecting the spread of the disease	7	Cooperative effort necessary	16
Control	7	Summary	17
Foreign and domestic red clovers	7		

DECLINE IN RED-CLOVER CULTURE

IT HAS BEEN CLEAR for some years that the acreage in red clover is declining, and this decline has been quite as pronounced in the southern and southeastern parts of the clover belt as elsewhere. The area in question includes Delaware, Maryland, Virginia, West Virginia, Kentucky, and Tennessee. (Fig. 1.) A study of the crop statistics for those States in the census reports of 1899, 1909, and 1919 shows that whereas the total acreage devoted to hay and forage increased steadily, the acreage in clover first declined and later rose a little, but, except in Tennessee, did not in 1919 reach the acreage of 1899 (fig. 2). The acreage in clover and even in timothy and clover did not keep pace with the demands for hay and forage during that period. In this area the only State showing a clover acreage in 1919 equal to that in 1899 was Tennessee, and in this case the increase was evidently due to the expansion of the crimson-clover area in the southern part of the State and not to red clover.

ANTHRACNOSE ONE CAUSE OF RED-CLOVER FAILURE

There are several causes for the failure of red clover, and these have been discussed in Farmers' Bulletin 1365 entitled "Clover Failure." These causes include lack of lime or of phosphorus, poor drainage, lack of organic matter, and diseases. There is consequently no one cure-all for clover failure. The cause may vary with locality, or more than one cause may operate in any locality, and the treatment will vary with the cause or causes producing failure.

Disease as a cause of clover failure is believed to be more important in the southern part of the clover belt than elsewhere, and on well-limed and fertile soils it is certainly the chief cause of clover failure in the territory mentioned. The purpose of this bulletin is to describe the anthracnose disease, to report on some experiences with red-clover seed from different sources when seeded in infected territory, and to call specific attention to the only remedy—the use of seed produced by plants resistant to this disease.

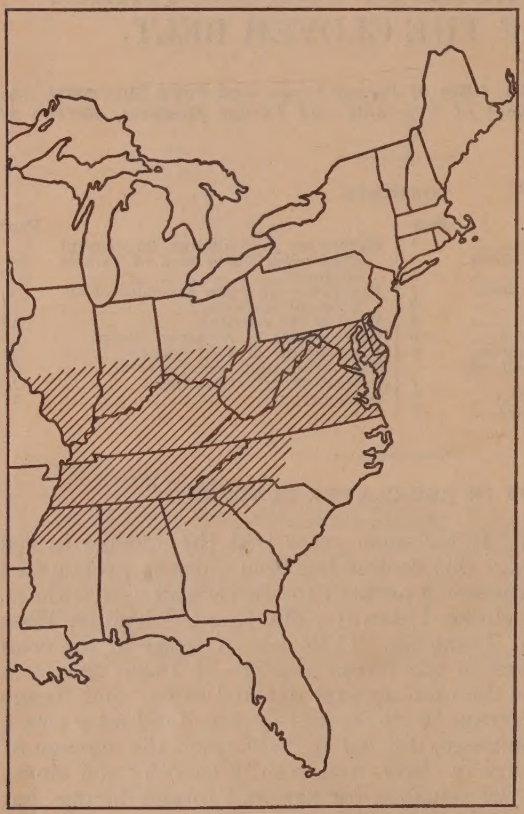

FIG. 1.—Map of the eastern portion of the United States showing the distribution of severe anthracnose trouble. Anthracnose is severe in all the shaded area, and a great deal of loss from the disease probably occurs also in the territory north and west of this area, but exact data are lacking

HISTORY AND DISTRIBUTION OF ANTHRACNOSE

In 1905, Professors Bain and Essary, of the Tennessee Agricultural Experiment Station, began investigations as to the cause of red-clover failure in Tennessee. After a survey of the State they concluded that the chief cause of failure was a disease produced by a fungus which they named "*Colletotrichum trifolii*." Recent studies indicate that this continues to be the most injurious disease affecting the crop in the southern part of the clover belt.

Although reported from practically all parts of the clover belt, this fungus is of greatest importance in the South. There is a very similar disease which is more destructive in the North, but this bulletin applies primarily to the anthracnose of the southern clover States, though it is possible that the area badly infected with the southern form of anthracnose extends farther north than the States here considered. A severe attack of this disease was observed at Urbana, Ill., in 1925, and much study is necessary before the infected area can be exactly delimited.

Of late years mildew has been widespread on red clover, so, to prevent any misunderstanding, it may be well to add that anthrac-

nose is *not* mildew. Mildew makes a white surface on the leaves and is much more conspicuous but not nearly so serious as anthracnose. The American type of red clover is more susceptible to mildew than the European, but as a rule it is less susceptible to anthracnose.

SYMPTOMS OF THE DISEASE

Anthracnose may attack plants either in the seedling stage or when they are fully mature. On seedlings it is most noticeable as spots on the petioles (leaf stems) or at the base of the leaflets. These spots first appear as soft discolored areas which later become shriveled and dark brown, finally turning black and brittle. The diseased area may occur as a small circular spot or as an elongated lesion extending the full length of the petiole. In either case the parts above the lesion usually wilt and bend back, making a characteristic hook at the point of infection. (Fig. 3.) One of the most susceptible parts of the plant is the short stalk of the leaflet. When infection occurs at this point the leaflet droops and finally dies, while the others on the same leaf may remain perfectly healthy. The result is similar to, and indeed often confused with, that produced by leaf weevils feed-

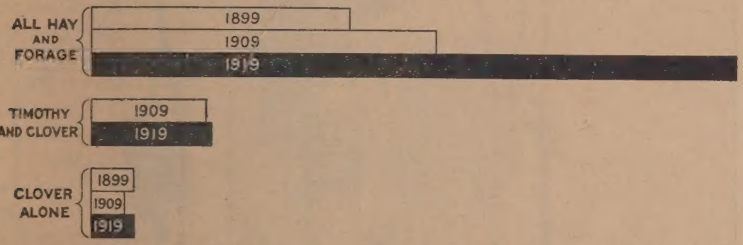

FIG. 2.—Diagram showing relative acreage of all hay and forage, of timothy and clover mixed, and of red clover alone, in Delaware, Maryland, Virginia, West Virginia, Kentucky, and Tennessee, according to United States census figures for years indicated

ing at the base of the leaflets; but in the case of weevil injury part of the stalk is found to be eaten away, whereas with anthracnose it simply shrivels and turns black. The disease may also be found on the leaf blade where it produces irregular dark brown or black spots of various sizes.

Anthracnose, when it occurs as described above, probably is not serious except in so far as it weakens and delays the development of the plant. By far the most serious damage is caused when the disease attacks the crown or the taproot, for in such cases there is no recovery. It may produce a general rot of the crown or cause on the taproot just beneath the surface of the soil a distinct dark lesion which resembles that described on the petiole. For a time the plant may be affected only on one side, but in the end it is usually encircled and soon dies. Such plants break off easily at the soil line, while the root system below the lesion appears entirely healthy.

NATURE OF INJURY THE FIRST SEASON

It is the injury to the crown of the plant which, between July and early September, causes heaviest losses in spring seedings and which

may practically destroy a stand of clover. Plants whose crowns or taproots are only slightly affected during the late summer may survive for several weeks or even through the fall months, but such injuries, though slight and unobserved, undoubtedly weaken the plant seriously and make it much more susceptible to other fungous or

FIG. 3.—Red-clover leaves attacked by anthracnose. Note the way the leaf stem is dried up at the point of attack

bacterial attacks. During the cool fall months the disease is checked so that plants slightly affected on leaves or petioles are able to survive, produce an apparently normal stand, and make a good growth even with part of the crown or taproot badly damaged. The test, however, comes during the winter months when all but healthy plants are destroyed. Many of the cases of so-called winter injury

are no doubt due to a severe thinning of the stand during the previous summer or to the death of plants during the winter as a result of the earlier injuries caused by anthracnose.

Figure 4 shows anthracnose injury on the taproot at the soil level. The leaves of a plant so attacked wilt, and in the course of a few days the entire plant collapses and there remains nothing but a bunch of dead leaves lying flat on the ground or supported by neighboring healthy plants. The disease is then spread from these dead plants to healthy ones by means of spores blown about or carried from plant to plant by spattering water. When seed of a highly susceptible strain has been sown the stand may be completely destroyed by September or October.

In extreme cases this dying of the plants may proceed so rapidly that in September the farmer sees only bare ground where some weeks before he had observed a good stand of clover, and consequently he is not aware of the cause of the failure.

Figure 5 shows the effect of anthracnose on red-clover seedlings of a highly susceptible strain, and Figure 6

FIG. 4.—Anthracnose injury on the taproot at soil level. Note the black area and wilted leaves. A plant injured as this one is dies before winter

shows plants of a highly resistant strain. Both photographs were taken at Arlington Experiment Farm, Rosslyn, Va., in August, 1923.

NATURE OF INJURY THE SECOND SEASON

On the first crop of the second year the disease is ordinarily most severe on the succulent stems, where it develops elongated dark lesions which in later stages may have a distinct black border with a brownish or grayish center. These lesions are often cracked or deeply furrowed down the center, causing the stem to curl back in a characteristic manner. They are especially frequent on stems just below the flower heads, although they may occur anywhere on the plant, as described in the seedling stage. After a field is badly attacked it has a brownish or blackened appearance owing to the

FIG. 5.—Plants of Italian red clover practically killed by anthracnose; seed sown in the spring of 1923. Note the large number of plants, showing that there was a good stand before the disease started. Compare with Figure 6

large number of dead leaves and plants. Within a week an apparently healthy field may be so generally affected that it looks as if fire had passed over it; in severe cases this is so striking that the disease has been called "scorch." (Fig. 7.)

However, unless a strain is very susceptible to anthracnose, the disease does not do a great deal of damage to the first growth. Clover grows very rapidly in the cool weather of early spring, and at that time conditions are not so favorable to the disease. When a clover stand comes through the winter in good shape a hay crop may confidently be expected. After the first cutting is harvested the disease appears to do its most serious damage at the crown or on the roots just beneath the soil level. Such infection may affect only a part of the plant, but as a rule it soon destroys the entire crown, causing death and total failure of the plant to recover growth.

CONDITIONS AFFECTING THE SPREAD OF THE DISEASE

Anthracnose is at its worst during periods of hot weather when there is abundant moisture. Under such conditions spores are produced rapidly and when carried to healthy plants these may develop the disease within three or four days. Spattering rain at such a time is probably the most effective means of distributing the fungus. Although new lesions are produced most rapidly in moist weather, it often happens that the effects of the disease are not noticeable until a dry period causes the infected plants to wilt and change color. The injury is then frequently attributed to "drying out," even though there may be plenty of moisture in the soil. When cool weather comes the attack is checked, and slightly affected plants may entirely recover. The fungus, however, remains in the field on

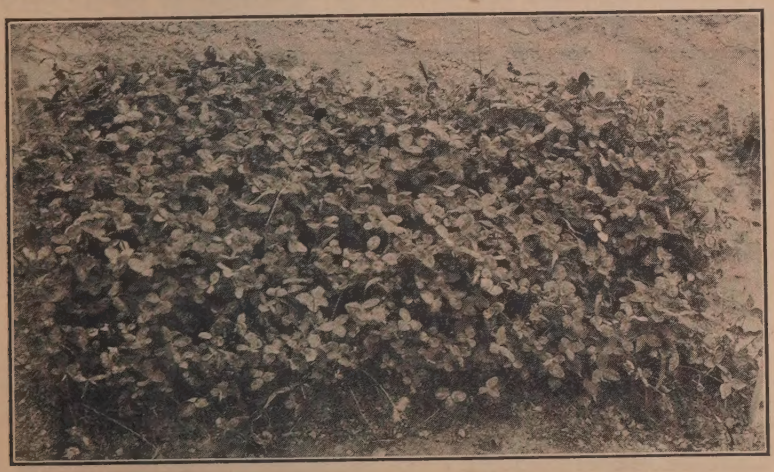

FIG. 6.—Young plants of a resistant strain of red clover. Note that there is some anthracnose, as shown by the dead leaves at the base of the plants, but they are able to withstand the disease and thrive in spite of it. Compare with Figure 5

diseased plants, and as soon as conditions are favorable it may be carried to healthy plants.

CONTROL

Since anthracnose is so widely distributed throughout the clover belt, and since volunteer plants which may carry the disease are to be found practically everywhere, there is little hope of controlling it by means of clean seed. In a crop like clover most of the methods used for controlling plant diseases are impracticable. The best means of combating clover anthracnose is by the development and use of strains of clover resistant to its attacks, a method advocated years ago by the Tennessee Agricultural Experiment Station, where Professors Bain and Essary developed such a strain.

FOREIGN AND DOMESTIC RED CLOVERS

During the last few years many observations have been made on the comparative resistance to anthracnose of strains of clover from

different countries and from various sections of the United States. As a result of these repeated observations it is evident that certain of the imported strains of red clover are extremely susceptible to this disease, and as a rule all are more susceptible than red clover from east of the Mississippi River. Exceptions occur, however, and our knowledge on this point is incomplete. Of the foreign clovers the strain grown in Italy is always most seriously injured by anthracnose. Seed from such a strain never proves satisfactory when planted in sections especially subject to anthracnose. The plants may overwinter at times and some years produce some hay, but as a rule they are killed out before spring, or, if not, they die soon after the first cutting and leave little on the field for plowing under but a crop of weeds. The use of American-grown seed does not solve the problem, for there is also found a wide range of susceptibility among our home-grown strains.

FIG. 7.—At the left is a red-clover plant dying with anthracnose; at the right is a healthy plant. Note the characterisic drying and shriveling of the leaves on the sick plant. (Arlington Experiment Farm, 1924)

At present there is only one distinct strain of red clover known to be highly resistant to anthracnose, though there appears no reason why other highly resistant strains should not be developed locally throughout the infected area. The strain referred to is the one developed by the Tennessee Agricultural Experiment Station several years ago. It is a vigorous strain which under the climatic conditions of Tennessee and neighboring States is capable of maintaining a heavy clover stand in spite of attacks of anthracnose. It does not, however, show up to such advantage when sown in the Northern States. The behavior of this strain demonstrates the advantages to be gained by developing and using clover which has become acclimated and suited to the local conditions under which it is to be grown; for example, a strain highly esteemed for its ability to withstand severe winters in the North may be extremely susceptible to anthracnose in the South. The importance of origin has been recognized in many other crops, but clover seed is usually purchased without regard to where it was produced. There is also some reason

for believing that red clover fairly resistant to anthracnose occurs locally throughout the territory defined. Seed from southern Ohio and from Maryland has in trials produced plants that withstood anthracnose almost as well as the selected Tennessee strain.

EXPERIENCE AT ARLINGTON EXPERIMENT FARM WITH CLOVER SEED OF VARIOUS ORIGINS

In the spring of 1922 several plots of red clover were growing at the Arlington Experiment Farm of the United States Department of Agriculture. The respective plots had been sown with seed from southern Ohio, Chile, Italy, Bohemia, and France, and with the exception of the last named, a good stand was obtained on all plots and the plants made a vigorous growth. The first cutting was not weighed, but the stand on the Chilean plot was rated the best. A few weeks after the first cutting the plants on the Ohio plot had a good second growth and were in bloom, whereas not one of the imported clovers recovered. The cause of this failure to recover was an attack of anthracnose. (Fig. 8.)

In the spring of 1922 triplicate series of plots were seeded on Arlington Farm with red-clover seed from various sources, including seed from Chile, France, Italy, England, and from other European countries, as well as from several States of the United States. Seed of the Tennessee anthracnose-resistant strain was seeded with the others. In September, 1922, it was noted that plants on many plots were dying, and the presence of anthracnose was determined. In May, 1923, some of the plots did not have one live clover plant, whereas the plots seeded to the Tennessee and the Ohio seed had a perfect stand. The total or nearly total destruction was confined to plots seeded to the most susceptible strains, but there was a rather heavy loss of plants on nearly all plots except those seeded with Tennessee and Ohio seed. (Figs. 9, 10, and 11.)

The clover series of 1924 was seeded in August of that year, and the anthracnose did no damage even to the susceptible strains. In June, 1925, the first cutting was weighed and very little difference was found in average hay yields from seed of different origins. The summer was dry, and the anthracnose did not appear until late. Nevertheless, the effect, though not so marked as sometimes, was to be noted in the reduced yield of the second cutting, especially on the plots seeded with Italian seed. Of American lots, those from Wisconsin and Minnesota were the most severely affected. There was no consistent difference in the behavior toward anthracnose among plants of north European, central European, French, or Chilean origin.

The fact that a good first hay crop and a fair second cutting were obtained from all imported as well as domestic red clovers at Arlington Experiment Farm in 1925 does not affect the conclusion that the use of any but resistant seed is risky. Seeding in August rather than in spring doubtless enabled the plants to escape serious injury in 1924, and the lack of rain in the early part of the summer of 1925 prevented a rapid spread of disease. Even with conditions so much in favor of the susceptible strains, they failed to equal the resistant strain in vigor and in quantity of hay produced.

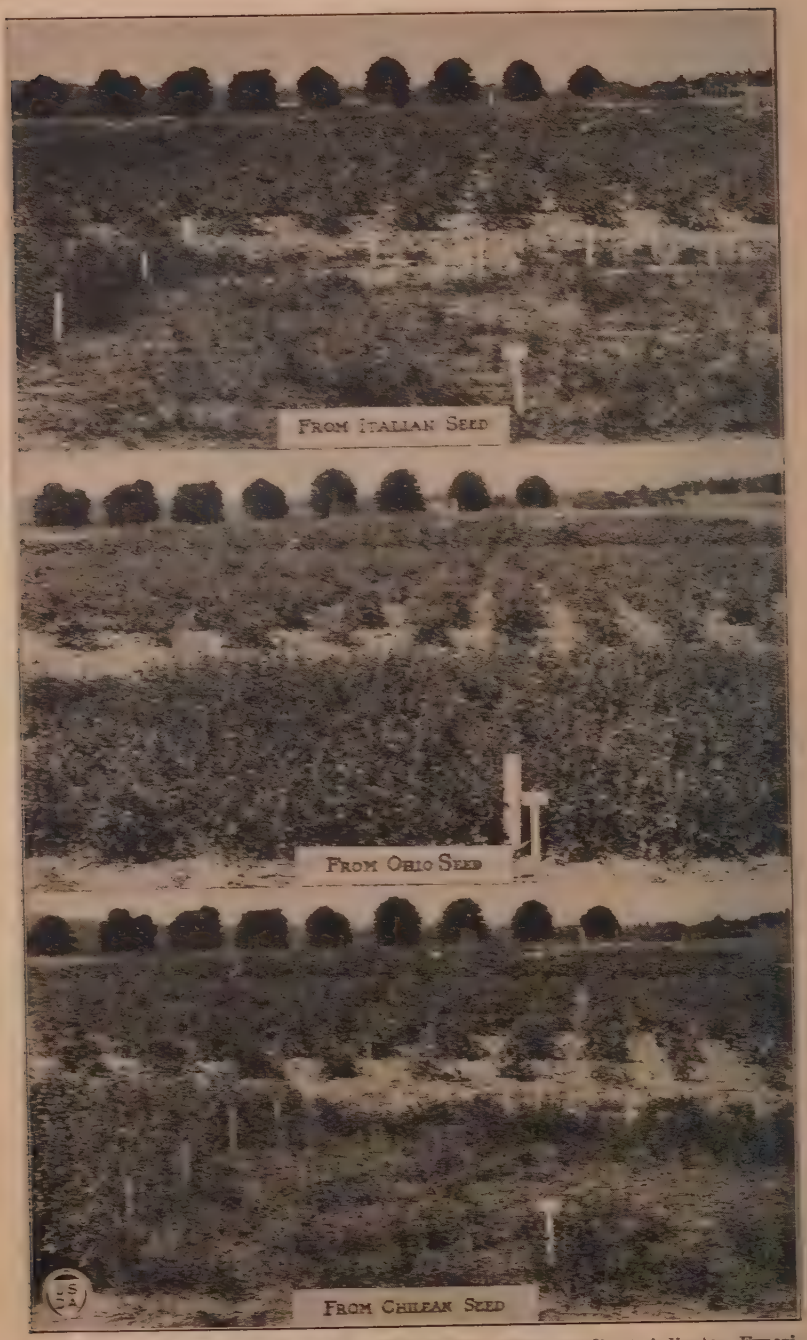

FIG. 8.—Second growth of clover on adjacent plots (foreground) at Arlington Experiment Farm, Va. Photographed July 21, 1922. The first growth of the Chilean plot was as good as that from Ohio seed

Such experiences and observations lead to the conclusion that all red-clover seed not grown in anthracnose-infected territory, unless grown elsewhere from a strain known to be resistant, is more or less unsuitable for use in the South, seed from Minnesota, Wisconsin, Oregon, and Canada being quite as much so as that from Chile and from France.

EXPERIENCE AT STATE AGRICULTURAL EXPERIMENT STATIONS

The testing of red clover from various sources has been carried on by the United States Department of Agriculture in cooperation with State agricultural experiment stations, among them those of Tennessee and Virginia. These stations are situated in the territory severely

FIG. 9.—Destruction by anthracnose of red clover of several strains, while plants of the Tennessee strain were uninjured. *A*, from Italy; *B*, from Tennessee; *C*, from Holland; *D*, from Poland; *E*, from Oregon; *F*, from Denmark

affected by anthracnose, and the experience with red clover at these stations has been similar to that at the Arlington Experiment Farm.

At the Virginia Agricultural Experiment Station at Blacksburg, in 1923, 90 per cent of the plants from Ohio and from Idaho seed recovered after cutting, whereas only 10 to 25 per cent of the plants from several imported lots recovered.

In 1924 this station harvested clover from a series of plots seeded to red-clover seed grown in Ohio, Michigan, Idaho, and Minnesota, as well as to that grown in various European countries and in Chile. The Tennessee anthracnose-resistant strain was used as a check. Yields from the Ohio and Tennessee seed were about the same, and both recovered well after the first cutting. Except for a small growth on the Chilean, not one of the imported lots recovered after

the first cutting, and the growth on some of the plots seeded to domestic seed was also poor. The poor recovery or failure to recover was due to anthracnose.

A third series of trials was conducted in 1924–25, and of these T. K. Wolfe, of the Virginia station, writes: "The present indications are that the resistance of the crops produced from seed from different sources to anthracnose is the chief factor in determining which source of clover will be best."

At Knoxville, Tenn., where trials have been carried on for several years by the Tennessee Agricultural Experiment Station, anthracnose is often more severe than it is at Blacksburg, Va. The spring seedings in some years have been destroyed by the disease, and when the stand has survived, frequently only one cutting has been obtained from susceptible strains. At this station the Tennessee anthracnose-resistant strain has each year produced two cuttings, whereas plants from seed grown in various other sections, both foreign and domestic,

FIG. 10.—Clover plots on Arlington Experiment Farm, Va., May 1, 1923. In the center, Tennessee anthracnose-resistant clover; to the right, Bohemian; on the left, Italian clover. There was a good stand of clover on all these plots in July, 1922, but later that year anthracnose destroyed most of the plants in the two side plots

have usually failed to make a second crop. Both Ohio and Maryland seed have given fairly good results, sometimes nearly equal to those from the resistant strain.

WHAT IS THE REMEDY?

There is obviously only one remedy to the present unsatisfactory condition of red-clover culture in the South, and that is the use of a strain or strains highly resistant to anthracnose. Farmers must be convinced of the value of seed from resistant plants; so well convinced, indeed, as to demand such seed and to be willing to pay a premium for it if necessary. Moreover, the farmer in the infected territory who grows resistant seed must take the trouble to produce it in clean condition. One difficulty at present with nearly all southern-grown red-clover seed is that it is foul with weed seeds, including dodder and buckhorn. Seed dealers are loath to buy

southern-grown red-clover seed because of the heavy loss in cleaning and the likelihood that it may be impossible to get rid of all the dodder and buckhorn. The condition that exists to-day is one that can be remedied only by the farmer. The seed trade will be glad to handle resistant seed when it is to be had, but the farmers of the South must produce it.

DEVELOPMENT OF RESISTANT STRAINS

The practice of using locally grown clover seed in sections subject to anthracnose has no doubt been discouraged not only by the small yield of seed which follows injury from this disease after the first

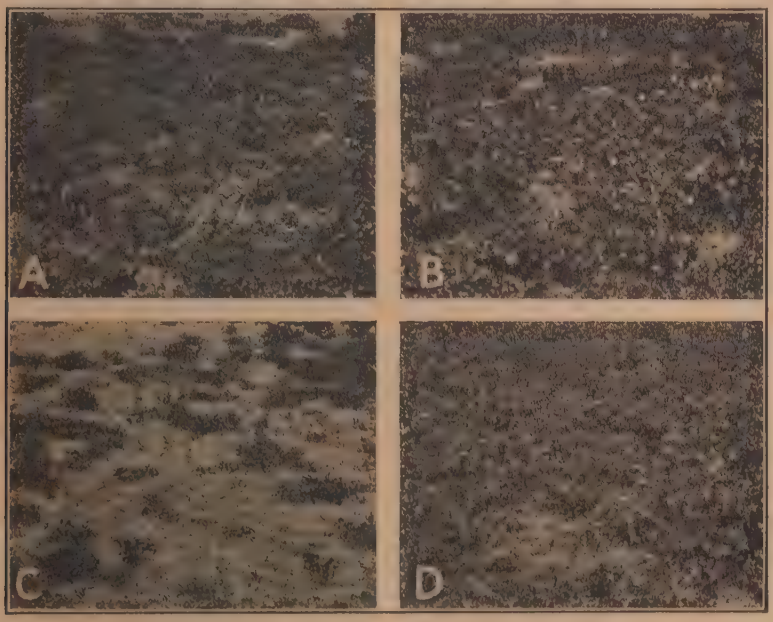

FIG. 11.—Clover plots on Arlington Experiment Farm, Va., May, 1923. These plots were sown with seed from different sources as follows: *A*, Chile; *B*, France; *C*, Minnesota; *D*, Ohio. There was an equally good stand on all plots in July, 1922. The difference in stand is the result of anthracnose injury

cutting but also by the fear that seed from badly infected fields may carry the fungus to new plantings. Many plant diseases, such as grain smuts, are carried in this manner, and farmers have learned the folly of using seed from infected sources. However, in the case of anthracnose, conditions are very different. The best seed will be produced by plants growing on infected fields when the plants are able to thrive and mature seed in spite of the disease. If no disease is present there may be a question whether the clover is or is not resistant; but when the plants grow in spite of the disease, as did the plants shown in Figure 7, there can be no question, and the fact of their survival may be taken as showing a high degree of resistance.

Highly resistant strains can therefore be developed best by selection from diseased fields. The danger of disease transmission by

seed is nullified by the superior resistance of the strains thus obtained.

To develop a strain of clover resistant to anthracnose it is necessary that it be grown in a district where the disease is regularly severe. If a field is heavily attacked the more susceptible plants are quickly killed and only the more resistant survive. Since the disease is very common on the stems just below the flowers, the seed heads of susceptible plants are commonly cut off before producing seed, so that only the more resistant plants survive and are able to reproduce. If the disease is severe the percentage of such seed heads may be low and appear to be not worth harvesting, but it is just such cases that give a start in the development of a resistant strain. If this seed is sown the following season and the plants are likewise again subjected to a severe attack, they will yield a higher percentage of resistant plants and undoubtedly a heavier seed crop. Thus a strain may be developed which, if regularly grown in a locality subject to the disease, will become more and more resistant through the natural elimination of the less vigorous plants and those more susceptible to anthracnose. By maintaining a good strain in one locality for many years and giving intelligent attention to selection, no doubt there may be developed strains much superior for local needs to any now in existence. A comparison of samples developed by farmers in different localities has clearly shown the possibilities in this direction.

It should be remembered, however, that there are many strains now on the market, especially those from Europe, which must be regarded as wholly unsuited for starting such a development. It would be a long process to develop an anthracnose-resistant stock from such a base in any section. Furthermore, if such seed is mixed with home-grown seed it is likely to weaken the stock by cross-pollination.

DEVELOPMENT OF SEED SUPPLIES

There is no doubt that the ideal toward which the agricultural interests in the area under discussion should aim is a commercial supply of seed of anthracnose-resistant clover. The development of such a supply is primarily a problem for the State authorities acting through the extension service and crop-improvement associations in each State. There is at present a limited supply of seed known to be of the true Tennessee resistant strain, and the officials of the Tennessee Agricultural Experiment Station are encouraging the production of larger quantities. Similar action might be taken by authorities of other States in this region.

For the successful development of a red-clover seed industry of this sort two things are necessary: The seed stock must be known to be from a resistant strain, and the fields must be kept free from weeds, at least from the more objectionable species, like dodder and buckhorn. The carrying out of such a program will therefore require certification of the seed based on field inspection. Such a program can best be organized by local and State authorities. Hand in hand with a campaign for seed production should go a persistent and effective campaign of education and demonstration,

so that farmers may become thoroughly convinced of the value of the resistant seed and willing to pay the premium which higher cost of production and greater value will warrant.

There is no inherent reason why red-clover seed should not be produced in quantity in the area under discussion. In fact, in 1924 Kentucky produced 1,920,000 pounds of clover seed, and it is said that not many years ago 3,500 bushels of red-clover seed were shipped out of the "northern neck" of Virginia every season. Red-clover seed is being produced to-day to a greater or less extent all over this territory, so that the problem of producing certified seed of a resistant strain would appear to be wholly one of organization and effort. Whatever the higher cost of such seed, an intelligent study of the facts as already presented shows that it is worth more than seed of unknown origin.

There is another source of good seed, but one of uncertain extent. It is known that throughout the southern part of the clover belt some farmers have produced their own seed for from 5 to 15 or perhaps more years from the same stock. It was stated above that in the trials which the department has been carrying on, seed from southeastern Ohio has given good results every year, and the same is true of seed produced in Maryland. At present there are not sufficient data to permit of more than the general statement that it seems probable that red-clover seed taken from plants grown in the infected territory (provided the stock has been grown locally for several years) will produce plants with a high degree of resistance to anthracnose. In this connection attention must be called to the facts that the severity of an attack of anthracnose depends largely on seasonal conditions and that it is quite possible to have a season in which a field seeded to susceptible northern-grown red-clover seed may produce a crop of seed. Such seed would not necessarily have any great value from the standpoint of resistance to anthracnose, and for this reason emphasis is placed on the length of time a stock of red clover has been grown in a given place.

The question has been raised whether the growing clover should be free from anthracnose to warrant certification. Unless it can be shown by the presence of anthracnose on other clover in the same neighborhood that the disease is present and severe, it seems wiser to require that anthracnose must be present on the clover inspected, but that the plants shall show ability to resist the progress of the disease.

In the Arlington Experiment Farm trials every year there has been some anthracnose on the plants of the Tennessee resistant strain; the plants were not immune, but instead of dying when infected they kept right on growing. Some lower leaves were lost, but the vigor of the plants seemed unimpaired. (Fig. 6.) For the present, therefore, and until more work has been done, it is deemed wisest to recommend that to warrant certification either as seed of a definite named resistant strain or as seed from plants highly resistant, even though not from a selected strain, field inspection should show that anthracnose is present in sufficient amount to warrant the expectation that the clover plants would have been killed or severely damaged if not resistant.

A third source of good seed may develop in case other clover-seed producing regions, such as Idaho, Oregon, or other States, procure stock of a highly resistant strain and produce commercial seed. This matter is mentioned here merely by way of suggestion; at present nothing is known about the practicability of such procedure. It is probable that seed of a resistant strain may be safely grown in non-infected territory for one or more generations and still retain its resistant characters. Experiments to determine this have been started, but at present there is no information, and indeed the matter is not one of immediate practical importance.

FALL RATHER THAN SPRING SEEDING

It is obvious that no matter what may be the outcome of the present effort to provide an adequate source of supply of the anthracnose-resistant seed, many farmers will for a long time to come buy red-clover seed of unknown origin. Some of this may be good, some bad, as far as resistance to anthracnose is concerned; and the question arises: What can be done to minimize the risk from the use of red-clover seed from nonresistant plants?

In many places the most practicable thing will be to seed alone in August rather than with a nurse crop in spring. August seeding can not be advised everywhere. It is said to be unsuccessful in Kentucky, largely because of the occurrence of dry weather in late summer. Whether or not this method will succeed in any particular section can be determined only by trial. In Virginia, some of the best stands of clover are procured by seeding in fall or late summer without a nurse crop, especially on thin land. Where land will produce 40 bushels or more of corn to the acre good stands may be obtained from spring seeding, but on land producing less than this, clover seeded alone in fall makes a better stand quite independent of the disease factor.

That the anthracnose disease is less serious on clover from August than on that from spring seeding has been observed repeatedly. This difference appears to be due to the fact that while red clover thrives in cool weather, the anthracnose does not. Consequently, the clover makes a fair to good hay crop in June before the disease becomes serious, but there is likely to be no second growth. Seeding in August to early September as moisture conditions may permit is recommended, therefore, as a means of reducing the chance of failure to hold a stand of red clover. With August seeding, where this is practicable, a reasonably good hay crop may be expected from imported seed, and if the season is favorable or the seed used was produced in the eastern United States a second growth may develop. If the second growth does not start, there will still be time to plow and sow cowpeas or soybeans for additional hay or for soil improvement.

COOPERATIVE EFFORT NECESSARY

The eventual solution of this problem will require the cooperative efforts of the United States Department of Agriculture, the State agricultural experiment stations and extension services, State and local crop-improvement associations, seedsmen, and, above all, the farmers of the territory in which the anthracnose disease is

prevalent. Unless the farmer is convinced that the trouble has been correctly diagnosed and that the proposed remedy is reasonable and presents a possible solution, no progress will be made. The farmer who produces clover seed must be willing to go to the trouble to produce good seed, and the one who buys must be willing to pay what good seed is worth.

In order that the area in which damage is done by anthracnose may be more exactly determined, the United States Department of Agriculture will be glad to receive any samples of sick or dying clover. The material should be collected before the leaves have dried up, as after the leaves are dry it is often too late to determine what killed the plants. Samples should be wrapped carefully and mailed to the Office of Vegetable and Forage Diseases, Bureau of Plant Industry, United States Department of Agriculture, Washington, D. C.

The following information will be of value if sent in connection with the samples: Date and place of collection; date on which the field was seeded; source of seed, if known; character of flowering stems produced (smooth or hairy); severity of the injury. In regard to the last point, a general statement that but few plants are dying or affected, that many are dying or affected, or that there is nearly complete loss of stand is all that is expected.

SUMMARY

The southern form of anthracnose is a limiting factor in clover culture in the South. It is not known just how widely distributed the disease is, but it is believed to exist to an unknown extent north of the Ohio River.

The only way to avoid loss from anthracnose is to use seed from a strain known to be resistant to the disease or seed produced from a stock propagated over a considerable period in the infected territory, even though the strain has not been especially selected for resistance to anthracnose.

Organized efforts should be made by local and State authorities to stimulate production of resistant seed and a demand for such seed.

As long as seed of unknown origin must be used, the department advises seeding in late summer or early fall wherever experience has not shown this to be impracticable.

Late summer or early fall seeding will give the clover plants a chance to escape the early attack of the disease and produce a hay crop even though there may be no second growth.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE

November 3, 1926

Secretary of Agriculture	W. M. JARDINE.
Assistant Secretary	R. W. DUNLAP.
Director of Scientific Work	A. F. WOODS.
Director of Regulatory Work	WALTER G. CAMPBELL.
Director of Extension Work	C. W. WARBURTON.
Director of Information	NELSON ANTRIM CRAWFORD.
Director of Personnel and Business Administration	W. W. STOCKBERGER.
Solicitor	R. W. WILLIAMS.
Weather Bureau	CHARLES F. MARVIN, *Chief.*
Bureau of Agricultural Economics	LLOYD S. TENNY, *Acting Chief.*
Bureau of Animal Industry	JOHN R. MOHLER, *Chief.*
Bureau of Plant Industry	WILLIAM A. TAYLOR, *Chief.*
Forest Service	W. B. GREELEY, *Chief.*
Bureau of Chemistry	C. A. BROWNE, *Chief.*
Bureau of Soils	MILTON WHITNEY, *Chief.*
Bureau of Entomology	L. O. HOWARD, *Chief.*
Bureau of Biological Survey	E. W. NELSON, *Chief.*
Bureau of Public Roads	THOMAS H. MACDONALD, *Chief.*
Bureau of Home Economics	LOUISE STANLEY, *Chief.*
Bureau of Dairy Industry	C. W. LARSON, *Chief.*
Office of Experiment Stations	E. W. ALLEN, *Chief.*
Office of Cooperative Extension Work	C. B. SMITH, *Chief.*
Library	CLARIBEL R. BARNETT, *Librarian.*
Federal Horticultural Board	C. L. MARLATT, *Chairman.*
Insecticide and Fungicide Board	J. K. HAYWOOD, *Chairman.*
Packers and Stockyards Administration	JOHN T. CAINE III, *in Charge.*
Grain Futures Administration	J. W. T. DUVEL, *in Charge.*

This bulletin is a contribution from

Bureau of Plant Industry	WILLIAM A. TAYLOR, *Chief.*
Office of Forage Crops	R. A. OAKLEY, *Senior Agronomist, in Charge.*
Office of Vegetable and Forage Diseases	H. A. EDSON, *Senior Pathologist, in charge.*

ADDITIONAL COPIES
OF THIS PUBLICATION MAY BE PROCURED FROM
THE SUPERINTENDENT OF DOCUMENTS
GOVERNMENT PRINTING OFFICE
WASHINGTON, D. C.
AT
5 CENTS PER COPY

▽